

## PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>AS/AM/P08180PC</b>	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. <b>PCT/GB 98/ 00863</b>	International filing date (day/month/year) <b>20/03/1998</b>	(Earliest) Priority Date (day/month/year) <b>21/03/1997</b>
Applicant <b>PETROLINE WELLSYSTEMS LIMITED et al.</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. ☐ **Certain claims were found unsearchable** (see Box I).
2. ☐ **Unity of invention is lacking** (see Box II).
3. ☐ The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing
  - ☐ filed with the international application.
  - ☐ furnished by the applicant separately from the international application,
    - ☐ but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
  - ☐ Transcribed by this Authority
4. With regard to the title,
  - ☐ the text is approved as submitted by the applicant
  - ☒ the text has been established by this Authority to read as follows:  
**EXPANDABLE SLOTTED TUBING STRING AND METHOD FOR CONNECTING SUCH A TUBING STRING**
5. With regard to the abstract,
  - ☒ the text is approved as submitted by the applicant
  - ☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this International Search Report, submit comments to this Authority.
6. The figure of the drawings to be published with the abstract is:  
Figure No. 2
  - ☒ as suggested by the applicant. ☐ None of the figures.
  - ☐ because the applicant failed to suggest a figure.
  - ☐ because this figure better characterizes the invention.

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 E21B17/08 E21B43/10 E21B43/08 F16L13/14

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 E21B F16L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	WO 96 37681 A (PETROLINE WIRELINE SERVICES LIMITED) 28 November 1996 see page 5, line 21 - page 7, line 2  ---	1-3, 5-7, 9, 10  11, 15, 16, 20
X A	WO 96 37680 A (SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ) 28 November 1996 see page 5, line 1 - page 6, line 22; figures 3, 4  ---	1-3, 5-7, 9, 10  11, 15, 16, 20
A	WO 93 25800 A (SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ) 23 December 1993 cited in the application  ---  -/-	

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

## \* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&amp;" document member of the same patent family

Date of the actual completion of the international search

17 July 1998

Date of mailing of the international search report

24/07/1998

Name and mailing address of the ISA

European Patent Office, P.B. 5618 Patentlaan 2  
NL - 2280 HV Rijswijk  
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Authorized officer

Sogno, M

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, X	WO 97 21901 A (PETROLINE WIRELINE SERVICES LIMITED) 19 June 1997 cited in the application see page 6, line 21 - page 10, line 2 ----	1-4, 8-10
E	WO 98 22690 A (SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ) 28 May 1998 see page 3, line 9 - page 4, line 7 -----	1, 3, 9-11, 15, 16

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 98/00863

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9637681	A	28-11-1996	AU 5826596 A	11-12-1996
			AU 7349396 A	11-12-1996
			WO 9637680 A	28-11-1996
			EP 0828918 A	18-03-1998
			EP 0824628 A	25-02-1998
			NO 975348 A	23-01-1998
			NO 975350 A	16-01-1998
WO 9637680	A	28-11-1996	AU 5826596 A	11-12-1996
			AU 7349396 A	11-12-1996
			EP 0828918 A	18-03-1998
			EP 0824628 A	25-02-1998
			WO 9637681 A	28-11-1996
			NO 975348 A	23-01-1998
			NO 975350 A	16-01-1998
WO 9325800	A	23-12-1993	AU 672008 B	19-09-1996
			AU 4324593 A	04-01-1994
			CA 2137565 A	23-12-1993
			DE 69305852 D	12-12-1996
			DE 69305852 T	22-05-1997
			DK 643795 T	14-04-1997
			EP 0643795 A	22-03-1995
			JP 7507611 T	24-08-1995
			MD 960219 A	31-05-1997
			NO 944746 A	03-02-1995
			NZ 253125 A	27-02-1996
			US 5366012 A	22-11-1994
WO 9721901	A	19-06-1997	AU 1068897 A	03-07-1997
WO 9822690	A	28-05-1998	NONE	

# PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

**PCT**

## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

United States Patent and Trademark  
Office  
(Box PCT)  
Crystal Plaza 2  
Washington, DC 20231  
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as elected Office

<b>Date of mailing (day/month/year)</b> 06 November 1998 (06.11.98)	
<b>International application No.</b> PCT/GB98/00863	<b>Applicant's or agent's file reference</b> AS/AM/PO8180PC
<b>International filing date (day/month/year)</b> 20 March 1998 (20.03.98)	<b>Priority date (day/month/year)</b> 21 March 1997 (21.03.97)
<b>Applicant</b> METCALFE, Paul, David	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:  
08 October 1998 (08.10.98)

☐ in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was  
☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

<b>The International Bureau of WIPO</b> 34, chemin des Colombettes 1211 Geneva 20, Switzerland	<b>Authorized officer</b> Eugénia Santos
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

## PATENT COOPERATION TREATY

D AS

From the  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

McCALLUM, W.  
CRUIKSHANK & FAIRWEATHER  
19 Royal Exchange Square  
Glasgow G1 3AE  
GRANDE BRETAGNE

*placed in spec*  
**PCT**NOTIFICATION OF TRANSMITTAL OF  
THE INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT  
(PCT Rule 71.1)Date of mailing  
(day/month/year)

19. 07. 99

Applicant's or agent's file reference  
AS/HS/PO8180PC

## IMPORTANT NOTIFICATION

International Application No.  
PCT/GB98/00863International filing date (day/month/year)  
20/03/1998Priority date (day/month/year)  
21/03/1997

Applicant

PETROLINE WELLSYSTEMS LIMITED et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

## 4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA



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## PATENT COOPERATION TREATY

## PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT



(PCT Article 36 and Rule 70)

Applicant's or agent's file reference <b>ASHS/PO8180PC</b>	<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/PEA/416)	
International application No. <b>PCT/GB98/00863</b>	International filing date (day/month/year) <b>20/03/1998</b>	Priority date (day/month/year) <b>21/03/1997</b>
International Patent Classification (IPC) or national classification and IPC <b>E21B17/08</b>		
Applicant <b>PETROLINE WELLSYSTEMS LIMITED et al.</b>		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 7 sheets, including this cover sheet.  
☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).  
These annexes consist of a total of 7 sheets.

## 3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand <b>08/10/1998</b>	Date of completion of this report <b>19. 07. 99</b>
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. (+49-89) 2339-0 Tx: 523656 apmu d Fax: (+49-89) 2339-4465	Authorized officer <b>Bellingacci, F</b> Telephone No. (+49-89) 2339 2784 

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**International application No. **PCT/GB98/00863****I. Basis of the report**

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.)*:

**Description, pages:**

2-13 as originally filed

1 as received on 09/07/1999 with letter of 08/07/1999

**Claims, No.:**

1-15 as received on 01/06/1999 with letter of 27/05/1999

**Drawings, sheets:**

1/2 as originally filed

2/2 as received on 19/06/1999 with letter of 17/06/1999

**2. The amendments have resulted in the cancellation of:**

- ☐ the description, pages:  
☒ the claims, Nos.: 16-20  
☐ the drawings, sheets:

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

**4. Additional observations, if necessary:**



**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB98/00863

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement****1. Statement**

Novelty (N)	Yes:	Claims	1-15
	No:	Claims	
Inventive step (IS)	Yes:	Claims	4,5,11-15
	No:	Claims	1-3, 6-10
Industrial applicability (IA)	Yes:	Claims	1-15
	No:	Claims	

**2. Citations and explanations**

see separate sheet

**VII. Certain defects in the international application**

The following defects in the form or contents of the international application have been noted:

see separate sheet

**VIII. Certain observations on the international application**

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

**INTERNATIONAL PRELIMINARY**International application No. **PCT/GB98/00863****EXAMINATION REPORT - SEPARATE SHEET**

Reference is made to the following documents:

D1 = WO,A,96/37680

D2 = WO,A,96/37681

**V - Reasoned statement under Rule 66.2 (a)(ii)**

V-1 D1, which is considered as the closest prior art, describes an expandable tubing assembly comprising:

- a tubular connector (page 4, lines 14-17 and claim 10) and
- lengths of expandable tubing defining overlapping longitudinal slots with nodes beyond the ends of the slots and having slotted end portions, the tubing being radially expandable by deformation of fingers of material where adjacent circumferentially spaced slots overlap (fig. 3).

The further features of claim 1 are new and therefore the claim meets the novelty requirement of Art. 33(3) PCT.

V-2 D1 does not disclose how the tubular connector should be designed. The solution of a female sleeve joining the male ends of two joints of tubing is however disclosed in D1 as an alternative to a case where a female end of a joint of tubing is connected to male end of the next joint (page 4, lines 14-17). The skilled man will find therefore obvious to design the connection between the female end of the tubular connector and the male end of a joint of tubing in the same way as D1 teaches to design the connection between the female end of a joint of tubing and the male end of the adjacent joint of tubing.

In said connection:

- the female end is slotted;
- male and female parts are connected by connecting means located in the nodes of male and female parts;
- the end most deformable fingers of the female part are axially spaced from the end most deformable fingers of the tubing length (see fig. 3).

The skilled man will find therefore obvious to provide said features also in the

**INTERNATIONAL PRELIMINARY**

International application No. PCT/GB98/00863

**EXAMINATION REPORT - SEPARATE SHEET**

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connecting tubular, but in doing so he will reach a device as in claim 1. Claim 1 therefore does not meet the inventive step requirement of Art. 33(3) PCT.

It is further pointed out that the subject-matter of claim 1 could even be seen as lacking novelty in the light of D1, as claim 1 does not specify that the tubular connector has two female ends, whereby already a length of slotted tubing could be seen as a "tubular connector", connecting the two adjacent length of tubing as defined in claim 1. In the light of the description the term tubular connector has been interpreted however as comprising two female ends.

**V-3** Connecting a female end and a male end of slotted tubing by means of threads machined on the nodes of the two parts is known, see page 3, lines 5-7 and 31-34 of D2.

Given the similarity between the assembly of D1 and D2, the skilled man will find obvious to provide the device of D1 with said feature of D2, and claim 2 therefore does not involve an inventive step.

**V-4** As it is apparent that it is advantageous to have a string of tubing with uniform characteristics, no inventive step can be seen in the subject-matter of claim 3.

**V-5** None of the cited documents makes suggests to join length of slotted tubing by means of a tubular connector having upset ends. Claim 4, and the dependent claim 5, meet therefore the inventive step requirement of Art. 33(3) PCT.

**V-6** The connection between tubing lengths as disclosed in D1 comprises a system of grooves (35) and tongues (36), and therefore the subject-matter of claim 6 does not involve an inventive step.

**V-7** The features of claims 7 and 8 are essentially identical to the ones of claims 1, whereby also said claims do not meet the inventive step requirements of Art. 33(3) PCT.

**V-8** Claim 9 specifies an obvious ways for designing a connecting sleeve, and therefore th claim does not involve an inventive step.

**INTERNATIONAL PRELIMINARY**

International application No. PCT/GB98/00863

**EXAMINATION REPORT - SEPARATE SHEET**

V-9 Claim 10 specifies an obvious method for connecting lengths of slotted tubing by means of a connector as in claim 1. As claim 1 does not meet the inventive step requirement of Art. 33(3) PCT, the same applies to claim 10.

V-10 D1, by merely suggesting that two length of slotted tubing can be connected by means of a sleeve, does not make obvious to join the two length by means of strips of material or by means of a sleeve with upset ends. As also the other documents in the proceedings do not make obvious said solution, independent claims 11, 14 and 15, and related dependent claims 12 and 13, meet the requirement of Art. 33(2) PCT.

V-12 Finally, it is pointed out that WO,A, 98/22690 has an effective filing date (i.e. a priority date) earlier than the filing date of the present application but it was published after said date. The document therefore is not part of the prior art as defined in Rule 64.1PCT. It is however possible that the document could be considered as part of the prior art, at least as far a novelty is concerned, by some national or international authority.

**VII - Certain defects**

VII-1 The independent claims are not properly cast in the two part form, with those features which in combination are part of the prior art (D1) being placed in the preamble, contrary to the requirements of Rule 6.3(b) PCT.

VII-2 The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

VII-3 The statement in the description, page 13, last paragraph, does not meet the requirements of Art. 6 PCT as interpreted in the PCT Guidelines, PCT/GL/3 III, 4.3a.

**VIII - Certain observations (clarity)**

VIII-1 To satisfy the conciseness requirement of Art. 6 PCT the set of claims should include only the minimum necessary number of independent claims in any one

**INTERNATIONAL PRELIMINARY**

International application No. PCT/GB98/00863

**EXAMINATION REPORT - SEPARATE SHEET**

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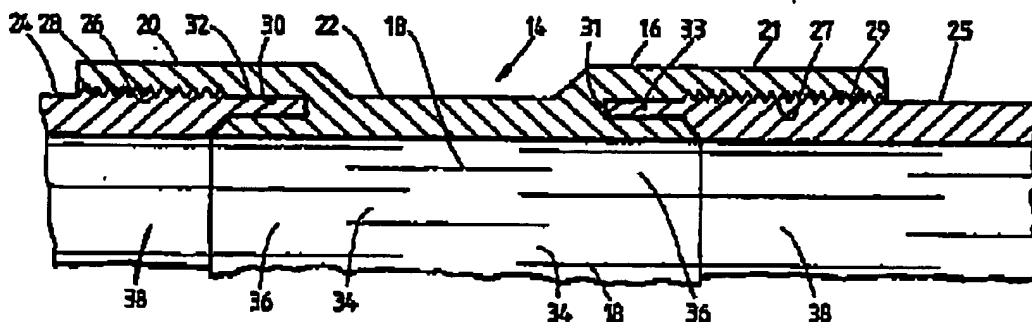
category. Said requirement is not satisfied by claims 1, 7, 10, 11, 14, 15, as in the present case it is considered appropriate to use only one independent claim in any category.

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification 6:</b> <b>E21B 17/08, 43/10, 43/08, F16L 13/14</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 98/42947</b> <b>(43) International Publication Date:</b> 1 October 1998 (01.10.98)
<b>(21) International Application Number:</b> <b>PCT/GB98/00863</b> <b>(22) International Filing Date:</b> 20 March 1998 (20.03.98) <b>(30) Priority Data:</b> 9705928.1 21 March 1997 (21.03.97) GB 9723338.1 4 November 1997 (04.11.97) GB <b>(71) Applicant (for all designated States except US):</b> PETROLINE WELLSYSTEMS LIMITED (GB/GB); Offshore Technol- ogy Park, Claymore Drive, Bridge of Don, Aberdeen AB23 8GD (GB). <b>(72) Inventor, and</b> <b>(75) Inventor/Applicant (for US only):</b> METCALFE, Paul, David (GB/GB); North Wing, Buckleburn Seading, Peterculter AB14 0NP (GB). <b>(74) Agents:</b> McCALLUM, William, Potter et al.; Cruikshank & Fairweather, 19 Royal Exchange Square, Glasgow G1 3AR (GB).	<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the</i> <i>claims and to be republished in the event of the receipt of</i> <i>amendments.</i>	

**(54) Title:** EXPANDABLE SLOTTED TUBING STRING AND METHOD FOR CONNECTING SUCH A TUBING STRING**(57) Abstract**

An expandable tubing assembly comprises a tubular connector (16) defining overlapping longitudinal slots (18), the connector (16) comprising end portions (20, 21) and an intermediate portion (22). The slots (18) extend over the whole length of the connector (16), but the only slot overlap occurs in the intermediate portion (22). The assembly further comprises lengths of expandable tubing (24, 25) defining overlapping longitudinal slots (12) and having end portions defining nodes (38) between and beyond the ends of the tubing slots (12). Tubing threads (28, 29) are formed on the end most tubing nodes. The connector end portions define threads (26, 27) and are coupled with the threads (28, 29) formed on the nodes of the respective end portions of the tubing lengths.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
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EE	Estonia						

2/PRTS

09/381508  
420 Rec'd PCT/PTO 21 SEP 1999  
PCT/GB98/00863

WO 98/42947

EXPANDABLE SLOTTED TUBING STRING AND METHOD FOR CONNECTING SUCH A TUBING STRING

This invention relates to a connector, and in particular to a connector forming part of an expandable tubing assembly. The invention also relates to a method of connecting lengths of expandable tubing.

5 WO93\25800 describes expandable tubing defining overlapping longitudinal slots. On expansion of the tubing, by pushing or pulling a mandrel through the tubing, the slots expand to form diamond-shaped apertures. The expansion is accommodated by deformation of the fingers of  
10 metal between the slots, this deformation taking place predominantly at the slot ends, and also by circumferential extension of the parts of the tubing wall beyond the slot ends. In expandable tubing developed by the applicants radial expansion is achieved with the parts of the tubing  
15 wall between and beyond the slot ends experiencing little if any deformation, these parts being known as the tubing "nodes".

Arrangements for connecting lengths of slotted tubing are disclosed in WO96\37687 and WO97\21901, the disclosures  
20 of which are incorporated herein by reference. Both of these documents describe arrangements in which the end of one length of tubing defines a male coupling portion which is received within a female coupling portion on the other length of tubing and attached thereto.

25 In another coupling arrangement, the ends of the tubing lengths are received within an external coupling



WO 98/42947

PCT/GB98/00863

2

sleeve. However, it has been found that, following expansion, the sleeve contracts radially by a significant extent; this creates a restriction in the bore defined by the tubing.

5 According to the present invention there is provided a method of connecting lengths of expandable tubing defining overlapping longitudinal slots, the method comprising:

10 providing a tubular connector defining overlapping longitudinal slots and comprising end portions;

providing lengths of expandable tubing defining overlapping longitudinal slots and having end portions defining nodes between and beyond the ends of the slots; and

15 connecting the connector end portions to nodes of respective end portions of the tubing lengths.

According to another aspect of the present invention there is provided an expandable tubing assembly comprising:

20 a tubular connector defining overlapping longitudinal slots and comprising end portions;

lengths of expandable tubing defining overlapping longitudinal slots and having end portions defining nodes between and beyond the ends of the slots; and

25 the connector end portions being coupled to the nodes of the respective end portions of the tubing lengths.

The formation of the connections between the connector end portions and the nodes of the tubing end portions provides for a relatively secure connection. Preferably,

WO 98/42947

PCT/GB98/00863

3

the connector end portions and the nodes of the tubing end portions are threaded, and the absence of significant deformation at the nodes facilitates maintenance of a secure connection on expansion of the tubing lengths and the connector.

Preferably also, the connector further comprises an intermediate portion selected to be of corresponding configuration to the tubing lengths, such that the expansion characteristics of the connected tubing assembly will be substantially constant over the connection.

Preferably also, each connector end portion defines a slot to receive a corresponding tongue provided on the respective tubing length end portion.

According to a further aspect of the present invention there is provided an expandable tubing assembly comprising:

a tubular connector defining overlapping longitudinal slots, the connector comprising end portions and an intermediate portion; and

lengths of expandable tubing defining overlapping longitudinal slots and having end portions coupled to the connector end portions,

at least the connector intermediate portion being of corresponding configuration to the tubing lengths, such that the expansion characteristics of the intermediate portion and the tubing lengths correspond.

This aspect of the invention provides a connector which expands in a compatible manner to the adjacent tubing and thus facilitates reliable expansion of an expandable

WO 98/42947

PCT/GB98/00863

4

tubing string.

According to still further aspect of the present invention there is provided an arrangement for coupling lengths of expandable tubing, the arrangement comprising a sleeve defining overlapping longitudinal slots, first and second tubing lengths defining overlapping longitudinal slots, in use the sleeve and tubing lengths being radially expandable by deformation of fingers of material where adjacent circumferentially spaced slots overlap, and connecting means for connecting the sleeve to the ends of the tubing lengths, the deformable fingers of the sleeve being axially spaced from the endmost deformable fingers of the respective tubing lengths.

In use, on expansion of the tubing lengths and the sleeve, the deformation of the sleeve fingers will take place following the deformation of the endmost fingers of the first tubing length and prior to the deformation of the endmost fingers of the second tubing length. It has been found that, following expansion, there is little or no diametrical shrinkage of the sleeve, and the force necessary to expand the coupled tubing ends is approximately half that required to expand tubing ends coupled with a sleeve in which there is substantial overlap between the sleeve and the tubing ends.

The invention also relates to a method for coupling the ends of first and second lengths of expandable tubing defining overlapping longitudinal slots and deformable fingers of material where adjacent circumferentially spaced

WO 98/42947

PCT/GB98/00863

5

slots overlap, the method comprising the steps of:

providing a sleeve defining overlapping longitudinal slots and deformable fingers of material where adjacent circumferentially spaced slots overlap;

5 coupling the sleeve to the ends of first and second lengths of expandable tubing such that the fingers of the sleeve are longitudinally spaced from the endmost fingers of the tubing lengths; and

10 forcing an expansion member through the connected tubing lengths to expand the sleeve and tubing lengths.

As used herein, the term slots is intended to encompass slots which extend through the walls of the sleeve and tubing, slots which extend only part way through the walls and any other appropriate weakening of the walls  
15 such as lines of bores or scallops.

Preferably, the connecting means are provided at circumferentially spaced locations at the end of the tubing lengths beyond the endmost tubing fingers, and at the ends of the sleeve beyond the respective endmost tubing fingers.  
20 The connecting means may comprise pins, rivets, screws and the like for location in appropriate aligned bores provided in the sleeve and tubing lengths. Single fasteners may be provided beyond each tubing finger, or multiple fasteners may be provided.

25 Preferably also, the unexpanded sleeve is of larger diameter than the tubing lengths. Most preferably, the sleeve and the tubing length are each of substantially constant diameter along their length.

WO 98/42947

PCT/GB98/00863

6

5

According to a still further aspect of the present invention there is provided an arrangement for coupling lengths of expandable tubing, the arrangement comprising a longitudinally slotted sleeve, first and second tubing lengths defining overlapping longitudinal slots, in use the tubing lengths being radially expandable by deformation of fingers of material where adjacent circumferentially spaced slots overlap, and connecting means for connecting the sleeve to the ends of the tubing lengths.

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The sleeve may be in the form of longitudinally extending strips of metal. Most preferably, the strips are rectilinear. On expansion, the strips of the sleeve move radially outwardly and separate circumferentially. Initially, that is prior to expansion, the strips may be circumferentially connected, by frangible links such as wire, webs of material or one or more welds, to facilitate sleeve handling.

20

The invention further relates to a method for coupling the ends of first and second lengths of expandable tubing defining overlapping longitudinal slots and deformable fingers of material where adjacent circumferentially spaced slots overlap, the method comprising the steps of:

25

providing a sleeve comprising longitudinally extending strips of material;

coupling the sleeve to the ends of first and second lengths of expandable tubing; and

forcing an expansion member through the connected tubing lengths to expand the sleeve and tubing lengths.

WO 98/42947

PCT/GB98/00863

7

Preferably, the connecting means are provided at circumferentially spaced locations at the end of the tubing lengths beyond the endmost tubing fingers, and at the ends of the sleeve. The connecting means may comprise pins, rivets, screws and the like for location in appropriate aligned bores provided in the sleeve and tubing lengths. Single fasteners may be provided beyond each tubing finger, or multiple fasteners may be provided.

Preferably also, the unexpanded sleeve is of larger diameter than the tubing lengths. Most preferably, the sleeve and the tubing length are each of substantially constant diameter along their length.

These and other aspects of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a sectional view of a length of expandable tubing, shown in an expanded configuration;

Figure 2 is a sectional view of an expandable tubing assembly in accordance with a first embodiment of the present invention;

Figure 3 is a schematic plan view of an arrangement for coupling lengths of expandable tubing in accordance with a second embodiment of the present invention;

Figure 4 is a sectional view of Figure 3; and

Figure 5 is a schematic plan view of an arrangement for coupling lengths of expandable tubing in accordance with a third embodiment of the present invention;

Reference is first made to Figure 1 of the drawings,

WO 98/42947

PCT/GB98/00863

8

which illustrates a length of expandable tubing 10. In its initial configuration, the tubing 10 is simply a length of pipe in which a series of longitudinal slots 12 have been machined. Applying a radially outward force to the tubing wall, by passing a mandrel through the tubing, causes the tubing to expand such that the slots 12 become diamond-shaped openings.

The tubing 10 is supplied in lengths suitable for transportation and handling and these are joined to one another on surface to create a tubular string. The assembly 14 illustrated in Figure 2 of the drawings allows lengths of expandable tubing 10 to be connected to form a string, as will now be described.

The assembly 14 comprises a tubular connector 16 defining overlapping longitudinal slots 18, the connector 16 comprising end portions 20, 21 and an intermediate portion 22. The slots 18 extend over the whole length of the connector 16, but the only slot overlap occurs in the intermediate portion 22.

The connector 16 is utilised to join the ends of two lengths of expandable tubing 24, 25, the ends of which are adapted to engage with the connector end portions 20, 21 as described below.

The connector intermediate portion 22 is of substantially the same wall thickness as the tubing 24, 25, however the connector end portions 20, 21 are upset, that is they include portions of greater wall thickness than the tubing 24, 25 and are of a greater diameter than the tubing

WO 98/42947

PCT/GB98/00863

9

24, 25. The inner walls of each connector end portion 20, 21 define threads 26, 27 for engaging corresponding threads 28, 29 on the outer surface of the tubing 24, 25. Inwardly of the threads 26, 27 the end portions 20, 21 define  
5 grooves 30, 31 to receive corresponding tongues 32, 33 provided on the ends of the tubing lengths 24, 25.

As noted above, the connector slots 18 only overlap in the intermediate portion 22, such that on expansion of the connector 16 and the tubing lengths 24, 25 the connector 16  
10 is only subject to significant deformation in the intermediate portion 22, at and adjacent the slot overlap 34. The amount of deformation is substantially lower in the rest of the connector 16, particularly in the "nodes" 36 between the ends of the longitudinally aligned slots 18.  
15 The tubing lengths 24, 25 feature nodes 38 between and beyond the ends of the tubing slots 12 and the tubing threads 28, 29 are formed on the end most tubing nodes.

In use, the tubing lengths 24, 25 are connected by first making up the connector 16 to one tubing length 24, and then making up the second tubing length 25 to the other  
20 end of the connector 16. A number of tubing lengths are connected in this way to form a tubing string, which is run into a wellbore. Once in a desired position, an expansion mandrel is run through the tubing string, and radially  
25 extends the connector 16 and the tubing lengths 24, 25. In doing so, the connector slots 18 and tubing slots 12 are expanded to define diamond shaped openings, as are illustrated in Figure 1. As described above the connector



WO 98/42947

PCT/GB98/00863

10

is only subject to substantial deformation at the slot overlaps 34, such that the metal of the slot end portions 20, 21 is subject to minimal deformation. As the deformation of the metal of the connector occurs primarily in the intermediate portion 22, which is of corresponding diameter and thickness to the tubing 24, 25, the expansion properties of the connector 16 are similar to the tubing 24, 25, such that the connector 16 and tubing lengths 24, 25 will expand in corresponding and predictable manner, minimising the occurrence of irregularities in the internal diameter of the expanded tubing string.

From the above description it will be apparent to those of skill in the art that the assembly 14 provides a convenient means for connecting expandable tubing lengths. It is recognised that, for some applications, users may prefer to include coupling means between the connector end portions and the tubing lengths in addition to the thread connection, and in such cases screws, rivets, pins or the like may be provided to extend between the end portions 20, 21 and the tubing lengths 26, 27.

Reference is now made to Figures 3 and 4 of the drawings which will illustrate an arrangement 50 for connecting first and second lengths 52, 54 of expandable tubing utilising an expandable sleeve 56 secured to the ends of the tubing lengths 52, 54 by screws 58. The tubing walls 60, 61 and the sleeve wall 62 define overlapping longitudinal slots 64, 65, 66. Expansion of the tubing lengths 52, 54 and the sleeve 56 is accommodated by

WO 98/42947

PCT/GB98/00863

11

deformation of fingers of material 68, 69, 70 where the slots 64, 65, 66 overlap, and following deformation the slots 64, 65, 66 define diamond-shaped apertures. During expansion there is little or no deformation of the nodes 72, 73, 74 between the longitudinally spaced slots 64, 65, 66, and the screws 58 pass through bores in the endmost nodes 72, 73, 74 of the tubing lengths 52, 54 and the sleeve 56, at the ends of the tubing lengths 52, 54 and sleeve 56. Thus, the endmost deformable fingers of the tubing lengths 68, 69 are axially spaced from the endmost fingers of the sleeve 70.

In use, the tubing lengths 52, 54 and sleeves 56 are shipped in disassembled form. The tubing lengths 52, 54 are made up on surface as the tubing is fed into the bore in which the tubing is to be utilised. In particular, the ends of the tubing lengths 52, 54 are located in the respective ends of the sleeve 56. The screws 58 are then located and tightened in the screw bores. A number of tubing lengths are made up to provide the desired length of tubing and the assembled tubing run into the bore. On reaching the desired location downhole, the tubing is anchored in place, and an expansion cone then pushed or pulled through the tubing. The cone expands the tubing length 52, 54 radially outwards such that, as mentioned above, the slots 64, 65, 66 become diamond-shaped, with the expansion being accommodated by deformation of the fingers 68, 69, 70. The sleeve 56 deforms in a similar manner to the tubing lengths 52, 54. On moving through the

WO 98/42947

PCT/GB98/00863

12

arrangement 50, the expansion cone deforms, in turn, the endmost fingers 68 of the first tubing length 52, the fingers 70a at the first end of the sleeve 56, the fingers 70b at the second end of the sleeve 56, and finally the endmost fingers 69 of the second tubing length 54.

In testing it has been found that the forces required to expand the connecting arrangement 50 are the same or only slightly higher than the forces required to expand the tubing lengths 52, 54. Also, the expanded sleeve 56 tends to retain its expanded form, and suffers little or no diametrical shrinkage after the expansion cone has passed through the sleeve 56. Thus, the present invention avoids the difficulties experienced with previously proposed sleeve connectors. Further, the connection arrangement 50 is less expensive to produce than the male/female connectors as described in WO96\37687 and WO97\21901.

Reference is now made to Figure 5 of the drawings, which illustrates an alternative arrangement 110 for connecting first and second lengths 112, 114 of expandable tubing utilising an expandable sleeve 116 secured to the ends of the tubing lengths 112, 114 by screws 118. The tubing walls define overlapping longitudinal slots 124, 125. However, unlike the first described embodiment, the sleeve wall is formed of individual longitudinally extending strips 126. Expansion of the tubing lengths 112, 114 and the sleeve 116 is accommodated by deformation of fingers of material 128, 129 where the slots 124, 125 overlap, and circumferential separation of the sleeve

WO 98/42947

PCT/GB98/00863

13

strips 126. Following deformation the slots 124, 125 define diamond-shaped apertures. During expansion there is little or no deformation of the nodes 132, 133 between the longitudinally spaced slots 124, 125, and the screws 118 pass through bores in the endmost nodes 132, 133 of the tubing lengths 112, 114 and the ends of the sleeve strips 126.

It will further be apparent to those of skill in the art that the above-described embodiment is merely exemplary of the present invention, and that various modifications and improvements may be made thereto, without departing from the scope of the present invention.

WO 98/42947

PCT/GB98/00863

14

CLAIMS

1. An expandable tubing assembly comprising:  
a tubular connector defining overlapping longitudinal slots and comprising slotted end portions, and  
5 lengths of expandable tubing defining overlapping longitudinal slots and having slotted end portions defining nodes beyond the ends of the slots, the connector end portions being coupled to the nodes of respective end portions of the tubing lengths.
- 10 2. The assembly of claim 1, wherein the connector end portions and the nodes of the tubing end portions are threaded.
3. The assembly of claim 1 or 2, wherein the tubular connector further comprises an intermediate portion between  
15 the end portions.
4. The assembly of claim 3, wherein the slots extend over the whole length of the connector, slot overlap occurring only in the intermediate portion.
5. The assembly of claim 3 or 4 wherein the intermediate  
20 portion is of corresponding configuration of the tubing lengths, such that the expansion characteristics of the connected tubing assembly are substantially constant over

WO 98/42947

PCT/GB98/00863

15

the connection.

5 6. The assembly of claim 5, wherein the connector intermediate portion is of substantially the same wall thickness of the tubing and wherein the connector end portions are upset.

7. The assembly of claim 6 wherein each connector end portion defines an internal thread for engaging a corresponding thread on an outer surface of the respective tubing end portion.

10 8. The assembly of any of the preceding claims wherein the connector end portions define grooves to receive corresponding tongues provided on the tubing length end portions.

15 9. A method of connecting lengths of expandable tubing defining overlapping longitudinal slots, the method comprising:

providing a tubular connector defining overlapping longitudinal slots and comprising end portions;

20 providing lengths of expandable tubing defining overlapping longitudinal slots and having end portions defining nodes beyond the ends of the slots; and

connecting the connector end portions to the nodes of respective end portions of the tubing lengths.

WO 98/42947

PCT/GB98/00863

16

10. An expandable tubing assembly comprising:

a tubular connector defining overlapping longitudinal slots, the connector comprising end portions and an intermediate portion; and

5 lengths of expandable tubing defining overlapping longitudinal slots and having end portions coupled to the connector end portions, at least the connector intermediate portion being of corresponding configuration to the tubing lengths, such that the expansion characteristics of the  
10 intermediate portion and the tubing lengths correspond.

11. An arrangement for coupling lengths of expandable tubing, the arrangement comprising a sleeve defining overlapping longitudinal slots, first and second tubing lengths defining overlapping longitudinal slots, in use the  
15 sleeve and tubing lengths being radially expandable by deformation of fingers of material where adjacent circumferentially spaced slots overlap, and connecting means for connecting the sleeve to the ends of the tubing lengths, the deformable fingers of the sleeve being axially  
20 spaced from the end most deformable fingers of the respective tubing lengths.

12. The arrangement of claim 11, wherein the connecting means are provided at circumferentially spaced locations at the end of the tubing lengths beyond the end most tubing  
25 fingers, and at the ends of the sleeves beyond the respective end most tubing fingers.

WO 98/42947

PCT/GB98/00863

17

13. The arrangement of claim 11 or 12, wherein the unexpanded sleeve is of larger diameter than the tubing lengths.

5 14. The arrangement of claim 13, wherein the sleeve and the tubing lengths are each of substantially constant diameter along their length.

10 15. A method for coupling the ends of first and second lengths of expandable tubing defining overlapping longitudinal slots and deformable fingers of material where adjacent circumferentially spaced slots overlap, the method comprising the steps of:

providing a sleeve defining overlapping longitudinal slots and deformable fingers of material where adjacent circumferentially spaced slots overlap;

15 coupling the sleeve to the ends of first and second lengths of expandable tubing such that the fingers of the sleeve are longitudinally spaced from the end most fingers of the tubing lengths; and

20 forcing an expansion member through the connected tubing lengths to expand the sleeve and the tubing lengths.

25 16. An arrangement for coupling lengths of expandable tubing, the arrangement comprising a longitudinally slotted sleeve, first and second tubing lengths defining overlapping longitudinal slots, in use the tubing lengths being radially expandable by deformation of fingers of



WO 98/42947

PCT/GB98/00863

18

material where adjacent circumferentially spaced slots overlap, and connecting means for connecting the sleeve to the ends of the tubing lengths.

5 17. The arrangement of claim 16, wherein the sleeve is formed of longitudinally extending strips of metal.

18. The arrangement of claim 17, wherein the strips are rectilinear.

10 19. The arrangement of claim 17 or 18, wherein the strips are initially circumferentially connected by frangible links.

15 20. A method for coupling the ends of first and second lengths of expandable tubing defining overlapping longitudinal slots and deformable fingers of material where adjacent circumferentially spaced slots overlap, the method comprising the steps of:

providing a sleeve comprising longitudinally extending strips of material;

coupling the sleeve to the ends of first and second lengths of expandable tubing; and

20 forcing an expansion member through the connected tubing lengths to expand the sleeve and tubing lengths.

09/381508

WO 98/42947

PCT/GB98/00863

1/2

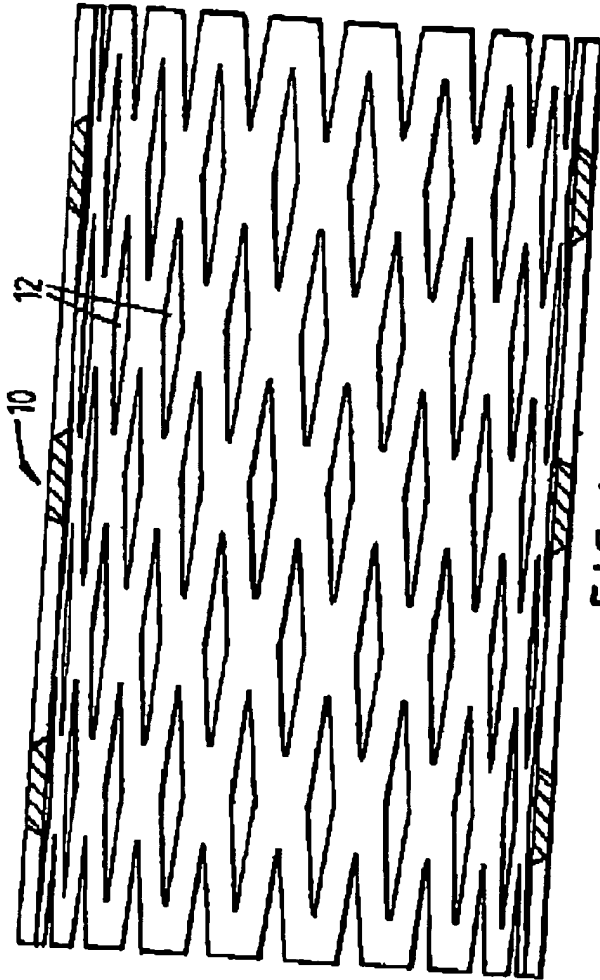


FIG. 1

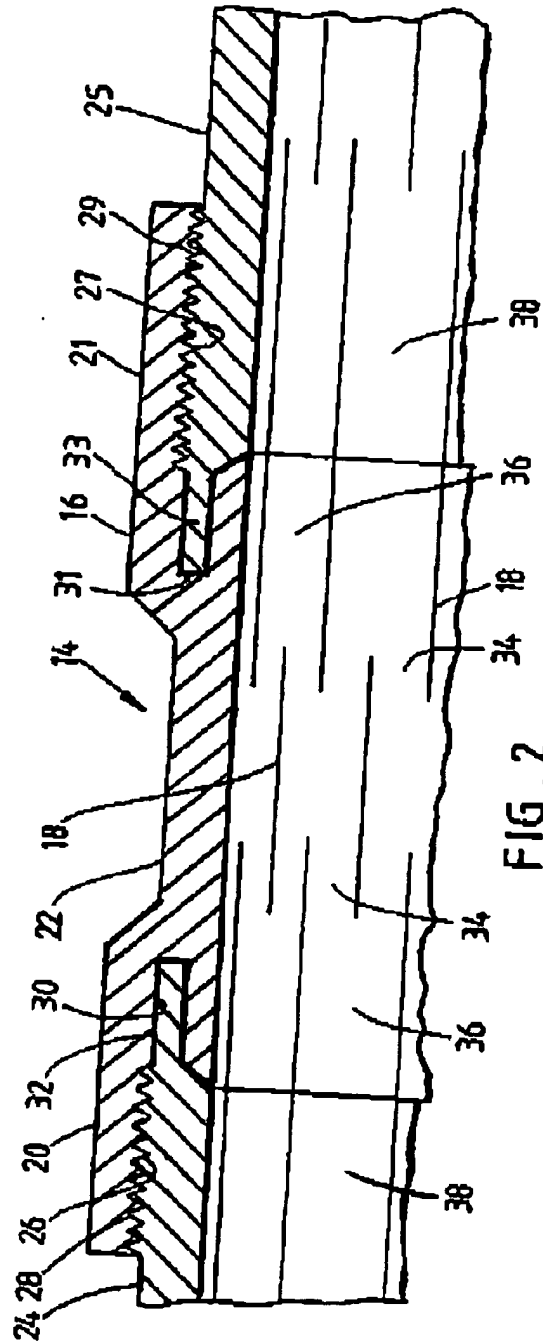


FIG. 2

WD 98/42947

09/381508  
PCT/GB98/00863

2/2

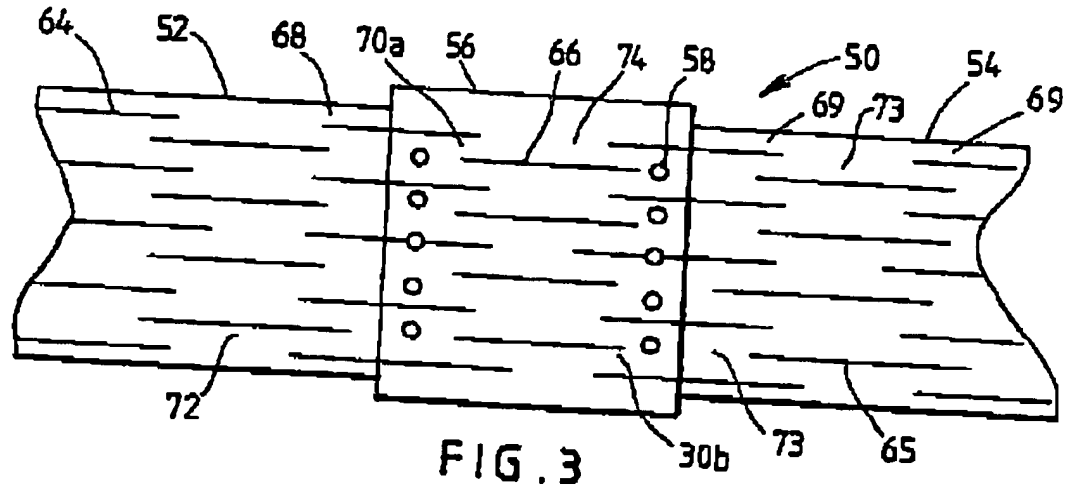


FIG. 3

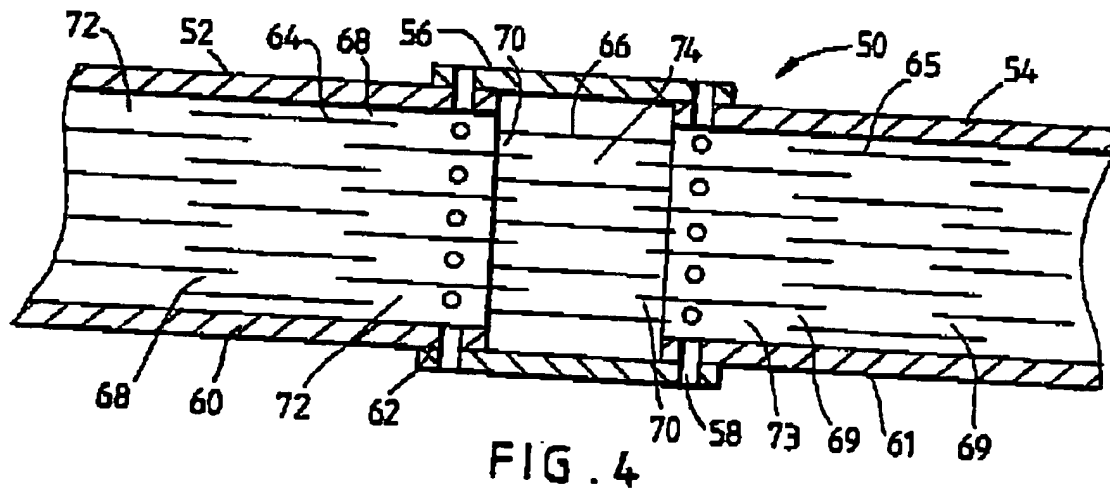


FIG. 4

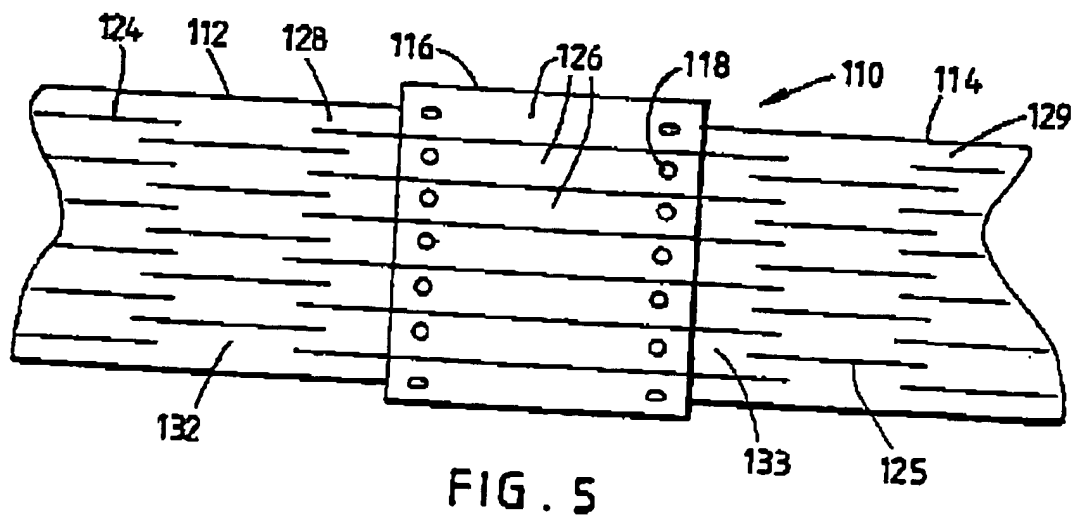


FIG. 5

# INTERNATIONAL SEARCH REPORT

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC 6 E21B17/08 E21B43/10 E21B43/08 F16L13/14		International Application No PCT/GB 98/00863
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) IPC 6 E21B F16L		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	WO 96 37681 A (PETROLINE WIRELINE SERVICES LIMITED) 28 November 1996 see page 5, line 21 - page 7, line 2	1-3, 5-7, 9, 10 11, 15, 16, 20
X A	WO 96 37680 A (SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ) 28 November 1996 see page 5, line 1 - page 6, line 22; figures 3, 4	1-3, 5-7, 9, 10 11, 15, 16, 20
A	WO 93 25800 A (SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ) 23 December 1993 cited in the application	
-/-		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C.		
<input checked="" type="checkbox"/> Patent family members are listed in annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document relating to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "Z" document member of the same patent family		
Date of the actual completion of the international search 17 July 1998		Date of mailing of the international search report 24/07/1998
Name and mailing address of the ISA European Patent Office, P.O. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx 31 651 epo nl Fax (+31-70) 340-3016		Authorized officer Sogno, M

## INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/GB 98/00863

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